

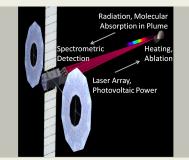
Completed Technology Project (2016 - 2017)

Project Introduction

We propose a system capable of probing the molecular composition of cold solar system targets such as asteroids, comets, planets and moons from a distant vantage. Our concept utilizes a directed energy beam to vaporize or sublimate a spot on a distant target, such as from a spacecraft near the object. With sufficient flux, our published results indicate that the spot temperature rises rapidly, and evaporation of materials on the target surface occurs (Hughes et al., 2015; Lubin and Hughes, 2015; Lubin et al., 2014). The melted spot serves as a high-temperature blackbody source, and ejected material creates a molecular plume in front of the spot. Molecular and atomic absorption of the blackbody radiation occurs within the ejected plume. Bulk composition of the surface material is investigated by using a spectrometer to view the heated spot through the ejected material. We envision a spacecraft that could be sent to probe the composition of a target asteroid, comet or other planetary body while orbiting the targeted object. The spacecraft would be equipped with an array of lasers and a spectrometer, powered by photovoltaics. Spatial composition maps could be created by scanning the directed energy beam across the surface. Applying the laser beam to a single spot continuously produces a borehole, and shallow sub-surface composition profiling is also possible. Our initial simulations of laser heating, plume opacity, material absorption profiles and spectral detectivity show promise for molecular composition analysis. Such a system has compelling potential benefit for solar system exploration by establishing the capability to directly interrogate the bulk composition of objects from a distant vantage. We propose to develop models, execute preliminary feasibility analysis, and specify a spacecraft system architecture for a hypothetical mission that seeks to perform surface molecular composition analysis and mapping of a nearearth asteroid (NEA) while the craft orbits the asteroid.

Anticipated Benefits

This system has a compelling potential benefit for solar system exploration by establishing the capability to directly interrogate the bulk composition of objects from a distant vantage.



This drawing illustrates a system concept for investigating the molecular composition of a distant target, such as an asteroid or comet. A spacecraft is sent to the asteroid, and enters into orbit. Solar cells generate electricity that is use...

Table of Contents

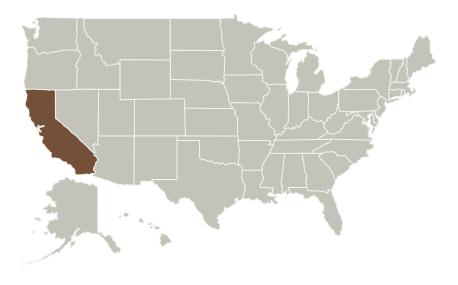
Project Introduction	1
Anticipated Benefits	1
Primary U.S. Work Locations	
and Key Partners	2
Project Transitions	2
Organizational Responsibility	2
Project Management	2
Technology Maturity (TRL)	2
Technology Areas	3
Target Destination	3
Images	4
Links	4



NASA

Completed Technology Project (2016 - 2017)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Туре	Location
California Polytechnic State University-San Luis Obispo(Cal Poly)	Lead Organization	Academia	San Luis Obispo, California
University of California-Santa Barbara(UCSB)	Supporting Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	Santa Barbara, California

Primary U.S. Work Locations

California

Project Transitions



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

California Polytechnic State University-San Luis Obispo (Cal Poly)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

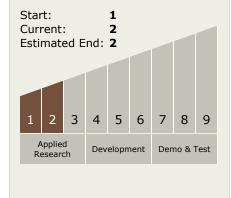
Program Manager:

Eric A Eberly

Principal Investigator:

Gary D Hughes

Technology Maturity (TRL)







Completed Technology Project (2016 - 2017)



June 2017: Closed out

Closeout Summary: This document is the Final Report for NASA Innovative Ad vanced Concepts (NIAC) Phase I Grant 15-NIAC16A-0145, titled Molecular Comp osition Analysis of Distant Targets. The research was focused on developing a sy stem concept for probing the molecular composition of cold solar system target s, such as Asteroids, Comets, Planets and Moons from a distant vantage, for exa mple from a spacecraft that is orbiting the target (Hughes et al., 2015). The orbi ting spacecraft is equipped with a high-power laser, which is run by electricity fr om photovoltaic panels. The laser is directed at a spot on the target. Materials o n the surface of the target are heated by the laser beam, and begin to melt and then evaporate, forming a plume of asteroid molecules in front of the heated sp ot. The heated spot glows, producing blackbody illumination that is visible from t he spacecraft, via a path through the evaporated plume. As the blackbody radiat ion from the heated spot passes through the plume of evaporated material, mol ecules in the plume absorb radiation in a manner that is specific to the rotationa I and vibrational characteristics of the specific molecules. A spectrometer aboard the spacecraft is used to observe absorption lines in the blackbody signal. The p attern of absorption can be used to estimate the molecular composition of mater ials in the plume, which originated on the target. Focusing on a single spot prod uces a borehole, and shallow subsurface profiling of the target's bulk compositio n is possible.

Closeout Link: https://www.nasa.gov/feature/molecular-composition-analysis-of-distant-targets

Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
 - ☐ TX09.4 Vehicle Systems
 - □ TX09.4.5 Modeling and Simulation for EDL

Target Destination

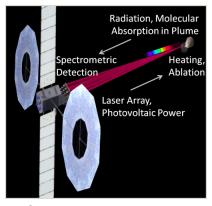
Others Inside the Solar System





Completed Technology Project (2016 - 2017)

Images



Project Image

This drawing illustrates a system concept for investigating the molecular composition of a distant target, such as an asteroid or comet. A spacecraft is sent to the asteroid, and enters into orbit. Solar cells generate electricity that is used to power a laser, which is directed at the asteroid's surface. The laser will heat a spot on the surface, and very quickly material will begin to evaporate from the spot. The glow from the heated spot is visible at the spacecraft through the plume of evaporated material. Sensors in the spacecraft measure the intensity of light across a span of wavelengths; analysis of light intensity patterns provides information about materials in the plume of evaporated material. Credits: Mark Pryor (Vorticity, Inc.), Gary B. Hughes (Cal Poly SLO) (https://techport.nasa.gov/imag e/102064)

Links

NASA.gov Feature Article (https://www.nasa.gov/feature/molecular-composition-analysis-of-distant-targets)

